HOOD FOR A VEHICULE PROVIDED WITH A MAIN WALL AND A INNER PANEL

The invention pertains to hoods of motor vehicles.

Hoods in metal material are known such as steel or aluminium. Said hoods have the disadvantage of being costly and of heavy weight. In addition, they are provided with a inner panel acting as reinforcement for the main wall of the hood which has areas of strong rigidity which prove to be adverse in the event of impact of a person's head on the hood.

Two specifications are recalled below relating to pedestrian impact injury:

- EEVC Wg 10: this concerns the impact of a head weighing 2.5 kg against the hood at an impact velocity of 40 km/h. The Head Injury Criterion (HIC) is less than 1000 (EEVC) ;
- ACEA ph1: the impact of a head weighing 3.5 kg against the hood at 35 km/h. In this case HIC values of 2000 are acceptable over one third of the hood surface.

Also, the constraints of static specifications are the following:

- hood indentation: under stress, deformation must be limited around the periphery of the hood and in its centre ;
- hood stiffness: the torsion angle under the hood's own weight must be low ; and
- hood robustness: when in raised position, the hood bearing on a rigid strut, associated with a load on the edge of the hood, the maximum permitted stresses must be less than the elastic limit of the materials used.

Other constraints also have to be observed when designing a hood:

- it must lend itself to assembly line painting and must therefore be able to withstand a maximum temperature of 205°C for 30 minutes ;
- it must have class A appearance ;
- it must be in line with the design and architecture of the vehicle ;
- it must absorb impact energy on impact ;

- an assembly system for the skin or inner panel must be provided ; and

- it must allow integration of fixtures such as hinges, latch catches etc.

The areas concerned by head impact are delimited according to whether the pedestrian is a child or adult. For small-size hoods the impact of a child's head applies to the entire surface area of the hood. For large-size hoods the impact of a child's head applies to the front part and the impact of an adult's head to the rear of the hood.

At the time of impact head deceleration is permissible if it does not last too long. The HIC criterion takes acceleration and time parameters into account defining a tolerance threshold. For example, if the acceleration undergone by the head is shown in relation to time, the corresponding curve may show a peak. In this case the maximum HIC is calculated by the below peak surface area. Said curve is illustrated for example figure 1. For a metal hood e.g. in aluminium, the head deceleration curve can be divided into several phases:

- an initial phase A corresponds to contacting of the head with the hood skin: the stiffness of the metal material influences skin deformation and the level of deceleration ;

- during a following phase B, it is the hood inner panel which is deformed: the acceleration curve increases either until the head contacts a hard point in the vehicle structure, or until the impact energy is dissipated, and

- during a final phase C, which relates to the position of impact, the contact with a hard point occurs: the deceleration peak is then at its maximum.

Figure 2 illustrates curves corresponding to hoods with a main wall in steel with steel inner panel, and with a main wall in aluminium with aluminium inner panel. As can be seen in this figure, the steel inner panel is stiffer than the aluminium inner panel. There is therefore less energy to be dissipated on contact with the hard point and a time shift in the peak can be seen compared with the steel-steel hood.

Also hoods are known whose inner panel is made in a brittle material which generates a different behaviour of the hood in the event of impact. This is the case with the hood in document WO 03/004263. Figure 3 illustrates the curve (2) corresponding to a hood having a main wall in aluminium and a inner panel in plastic material obtained by Bulk Moulding Compound (BMC). It is seen that phase A is common to phase 1 of the aluminium-aluminium hood so that the stiffness of the main wall or skin is preponderant. With the brittle inner panel, phase B does not show any increase in acceleration since rupture occurs under the force applied by the head. Peak C which corresponds to contact with the hard point is high. Therefore the energy dissipated by rupture of the inner panel proves to be insufficient.

Patent WO 03/004263 particularly presents a hood consisting of a skin and inner panel assembly, the inner panel being in a brittle, laminate material. This inner panel design does not enable static robustness criteria to be met. Said hood does not prove to be satisfactory if hard points are taken into account representing the vehicle structure.

One purpose of the invention is to provide a hood having more satisfactory performance.

For this purpose the invention provides for a vehicle hood comprising:

- a wall containing a first material, and
- an inner panel containing a second more brittle material than the first material, the inner panel comprising ribs.

Surprisingly and as will be seen below, the presence of ribs makes it possible to modify substantially the behaviour of the hood while making it fully compliant with the above-cited specifications.

The inventive hood may also have at least one of any of the following characteristics:

- at least one of the ribs is planar ;
- at least two of the ribs are perpendicular to each other ;
- at least two of the ribs are parallel to each other ;

- at least one of the ribs is perpendicular to the wall ;
- the ribs extend over only part of the inner panel surface ;
- the ribs extend into at least one zone of the inner panel chosen from among:
    - a front half ;
    - a rear half ; and
    - a front lateral edge zone
- at least some of the ribs extend along a general direction perpendicular to a direction of the hood edge that is closest to these ribs ;
- at least some of the ribs are inclined with respect to a longitudinal direction of the vehicle ;
- at least some of the ribs each consist of a single planar rib wall ;
- at least some of the ribs have free, upper end longitudinal edges ;
- at least some of the ribs form open mutually contiguous cells, in particular open upwardly ;
- at least one of the ribs is not in contact with the wall
- the inner panel comprises at least one guard
- the guard or at least one of the guards is of elongate shape along a rectilinear axis, e.g. parallel to a longitudinal direction of the vehicle ;
- the guard or at least one of the guards is of elongate shape along a non-rectilinear axis,
- the guard or at least one of the guards is not in contact with the wall ;
- the wall being the wall of the hood, the guard or at least one of the guards has a guard wall locally parallel to the wall of the hood and without contact with the latter ;
- the wall of the guard extends on the side of the guard which is closest to the hood ;
- the first material contains a metal such as steel or aluminium ; and
- the second material is chosen from the group consisting of:
    - a thermodur obtain by sheet moulding compound
    - a thermodur obtained by bulk moulding compound; and

- a fibre-reinforced thermoplastic.

Other characteristics and advantages of the invention will become more apparent in the following description of two preferred embodiments given as non-limitative examples with reference to the appended drawings in which

- figures 1 to 3 are graphs illustrating time-related acceleration after impact with different types of hoods, the hood according to a first preferred embodiment of the invention corresponding to one of the curves in figure 3.
- figure 4 is a perspective view of the hood inner panel according to the first embodiment of the invention, with the main wall removed ;
- figure 5 is a partial perspective view on a larger scale of the hood in figure 4 ;
- figure 6 is a plan view of the hood in figure 4 with the main wall ;
- figure 7 illustrates the typical curve of a brittle material ;
- figures 8 and 9 give the results of respective tests for the hood in figure 4 and a prior art hood ;
- figures 10 and 11 also give the results of these tests ;
- figure 12 is a similar graph to the one in figures 1 to 3 showing the results of different types of tests ;
- figure 13 is a schematic view of the hood in raised position on its support strut ;
- figures 14 and 15 are two cross-section views showing the impact of a hood with a test impactor in the case of a prior art hood and the hood in figure 4 respectively ;
- figure 16 is a diagram illustrating the maximum stresses in different hoods ;
- figure 17 is a perspective view of the inner panel of a hood according to second preferred embodiment of the invention,
- figure 18 is a plan view of the left half of the inner panel in figure 17 ; and

- figure 19 is a cross-section view of the inner panel along the plane XIX-XIX in figure 18.

Figure 4 illustrates a perspective view of the general arrangement of a hood according to a first preferred embodiment of the invention. Figure 5 is a view on a larger scale of the left corner of the hood in figure 4 showing part of the inner panel in transparency i.e. as if the main wall had been removed. The main wall of the hood is also illustrated figure 6 which gives a plan view of the hood.

The hood 2 therefore comprises a main outer wall 4 which here is in metal, and in this case is aluminium. It also comprises an inner panel 6 intended to be fixed against the inner surface of the main wall 4, therefore being invisible from outside the vehicle. The inner panel 6 extends over only part of the surface of the wall 4 (and more precisely under this surface). It therefore extends along the rear 8, front 10, left 12 and right 14 edges of the main wall 4.

The inner panel 6 has ribs 20. These ribs extend over one or more parts of inner panel 6, here at the left 22 and right 24 rear corners of the main wall 4. The ribs 20 of each zone, here, are all planar and perpendicular to the general plane of wall 4. In addition, as illustrated figure 5, five of the ribs are parallel to one another lying at a distance and opposite one another. They extend substantially along the direction of movement of the vehicle. They are also perpendicular to another of the ribs which intercepts each of the five above-mentioned ribs. The ribs therefore form a network or mesh of contiguous, upwardly open cells, these cells not being closed in their upper part by the upper wall 4 as shown figure 15.

As arises from the drawings the rib which intercepts the others extends along a general direction parallel to the general plane of the hood and perpendicular to the direction of the lateral edge 12 of the hood which is the closest to this rib. All the ribs consist here of a single planar rib wall. Their upper end longitudinal edges are free, extending at a distance from wall 4.

The inner panel 6 with ribs 20 consists of a more brittle material then the material of wall 4. The typical characteristics of a brittle material are illustrated in the curve figure 7 which shows changes in stresses undergone by said material in relation to its deformation. A first phase can be distinguished during which this stress increases in relation to deformation until it culminates in a yield limit corresponding to the fissure point. During the subsequent phase, the stress decreases as deformation increases until it cancels out at the yield point corresponding to erosion of the element.

The brittle material here is a plastic material. It can preferably be chosen from among the following families:

- a thermodur obtained by Sheet Moulding Compound (SMC) ;
- a thermodur obtained by Bulk Moulding Compound (BMC) as is the case here ; and
- a fibre-reinforced thermoplastic.

Figure 3 shows a curve (3) corresponding to the hood just described. It can be seen that phase A is different from the preceding cases. It shows greater acceleration due to the stiffness of the inner panel, a stiffness that is complementary to the stiffness of the wall 4 or skin. Phase B shows the behaviour of a brittle inner panel as explained above. On the other hand this case shows that the energy dissipated by rupture of the ribbed inner panel is higher and that the contact with the hard point occurs without any acceleration peak. Therefore the time window for HIC calculation is wider with slower accelerations. Under these conditions, the HIC value meets pedestrian injury specifications.

Figures 8 and 10 show the test results of the above-mentioned inventive hood at the time of child impact, the position of the impactors being illustrated figure 6. As can be seen the HIC value is lower than 2000 over the entire hood and is less than 1000 on one of the zones which here is a central zone. On the contrary, figures 9 and 11 give the

results of a similar test on a prior art steel-steel hood: at certain points the HIC is higher than 3500.

It was ascertained that the choice of impactor also has an influence on hood behaviour at the time of pedestrian impact. Figure 12 gives several curves, in particular curves (4) and (5) which represent the behaviour of a prior art aluminium-aluminium hood as per two specifications: EEVC and ACEA ph1 impactors. Phases A, B and C previously described can be identified on each of the two curves. It can be seen that the global acceleration level of curve (5) is distinctly smaller than in curve (4). This phenomenon can be explained by the velocity of impact which is slower with an ACEA impact. The accelerations and energy levels are lower and the time window for HIC calculation is wider in ACEA which means that the HIC value is lower.

Nonetheless this phenomenon is identifiable irrespective of hood type. For example curve (6) shows the behaviour of a prior art steel-steel hood, and curve (7) shows the behaviour of the inventive hood described above. In the latter case the HIC value is 50% lower, and fully meets pedestrian injury specifications.

Figures 14 and 15 illustrate two examples of the position of the impactors over a prior art hood with its metal inner panel and over the above-mentioned inventive hood 2 with the ribbed inner panel 6 in synthetic material.

The inventive hood satisfactorily meets static specifications. For example, figure 13 schematically illustrates the inventive hood in raised position on a supporting strut. A simulation indicates that the maximum stresses, observed in the areas of the skin and inner panel on which demand is placed, are not excessive. The stresses undergone by the inner panel are lower than those undergone by a metal inner panel and are at all times lower than the elastic limit of the material, here 80 Mpa. Consequently the above-mentioned BMC inner panel 6 shows no irreversible deformation. In an inventive hood, the main wall 4 always has a higher stress level than the inner panel 6, the inner panel

being less stiff and the main wall working harder so that stress is higher. By way of comparison, figure 16 illustrates the stress levels undergone in the zones of maximum stress for different prior art hoods and the inventive hood.

The inner panel 6 of above-mentioned hood 2 could be made by injection of compression moulding. This inner panel is then assembled to the skin 4 by gluing or crimping. For example the glue could be pre-polymerized when positioning the inner panel on the skin. During the subsequent temperature rise of the hood after cataphoresis treatment the polymerisation process of the glue is completed. The hood can then be painted at the same time as the remainder of the vehicle body.

A second preferred embodiment of the invention is shown figures 17 to 19. The hood 102 of this second embodiment is similar to the first embodiment except in respect of some characteristics, amongst the following, regarding the inner panel 106. The inner panel is symmetrical with respect to the median longitudinal plane of the hood and vehicle.

The inner panel 106 comprises a first set of ribs 120 forming a zone 130 in strip form along the rear edge 8. This zone extends into the rear third of the inner panel and over a width equal to approximately 4/5 of the width of the inner panel at this point. In this zone the ribs 130 extend along the longitudinal direction of the vehicle. They here total a number of 14 but this number could be increased or reduced.

The inner panel comprises two other sets 132, 134 of ribs 120 extending in the front half of the inner panel respectively along left 12 and right 14 edges. The ribs are oriented, from a plan view, along a direction parallel to the general plane of the inner panel and locally perpendicular to edge 12, 14 to which they are the closest. They are, from a plan view, inclined with respect to the longitudinal direction of the vehicle. The ribs here total a number of 5 on each side, but this number could be modified.

The inner panel comprises a front set 136 of ribs 120. This set extends in the front half of the inner panel, away from the front edge 10 and close to the front edge 138 of a

central opening 137 in the inner panel, this edge being of curved shape whose centre of curvature is on the side of the edge opposite opening 137. The ribs are oriented in the same manner as those in zone 130 and here total a number of 14. All the ribs of the above-cited zones each consist of a single vertical planar wall (in the rear 130 and front 136 zones) or are inclined with respect to the vertical (lateral zones 132, 134). They are therefore similarly either perpendicular to the wall 4 of the hood or inclined with respect to this wall.

At least some of the ribs in each zone are parallel to one another (lateral zones 132, 134) or are even all parallel (rear 130 and front 136 zones).

All these ribs have free, upper end longitudinal edges 141. As can be seen figure 19, this edge in lateral zones 132, 134 extends away from wall 4 of the hood. The same could apply to the other above-mentioned ribs.

These ribs in pairs form cells that are mutually contiguous and upwardly open. The ribs are connected to the wall of the inner panel by their lower longitudinal edge as illustrated figure 19.

Some zones of the inner panel are devoid of ribs such as the zone alongside the front edge 10 or the rear left 22 and right 24 corners.

The inner panel 106 also comprises here guards 140, 142.

The guards 140 extend forwardly along the front edge 10 and ahead of zone 136. Here they total 6 in number but this number could vary. The guards 140 are profiled along a rectilinear axis parallel to the longitudinal direction of the vehicle. They are spaced apart.

The guards 140, 142, extend into the rear left 22 and right 24 corners. They are profiled along a curved axis but lie within the general plane of the inner panel. Each corner comprises a pair of guards 142 of curved shape, from a plan view, following the local contour of the corner of opening 137 and having a centre of curvature located on the same side of the guard as the opening.

All the guards 140, 142 here have an upturned U-shaped profile, the base of the "U" forming the apex of the guard and its part closest to the wall 4. The apex is formed by a guard wall which is planar, facing wall 4 parallel to it locally and distanced away from it. The guards do not all have the same thickness, and in each guard this thickness varies along the length of the guard, its apex remaining locally parallel to the wall 4.

Evidently, numerous modifications could be made to the invention without departing from the scope thereof.

All or part of the guards could be replaced by reinforcements of truncated cone shape whose axis is perpendicular to the general plane of the hood.

The main wall could be in steel rather than in aluminium. It could be made in at least one composite material containing a plastic material and glass fibres. This material alone could form the main wall.

It could also be in sandwich plate consisting for example of two outer metal layers either side of a central layer in plastic material. In such case the wall 4 could therefore comprise a composite material formed of at least two materials, and the material of the inner panel must be more brittle than the composite material of the wall.

Provision could be made for the inner panel to be mounted on the hood while the vehicle is on the assembly line, after cataphoresis treatment and just before the vehicle enters the painting station. The inner panel must then resistant en exposure temperature of approximately 120°C.

Alternatively, it could be provided to paint the inner panel before it is mounted on the vehicle e.g. at a sub-contractor of the vehicle manufacturer. In this case it must resist a temperature of approximately 80°C.

A vehicle hood could be made comprising:

- a wall containing a first material ;

- an inner panel containing a second material more brittle than the first material and reinforcements such as guards without comprising any ribs.